RESEARCH INFRASTRUCTURE IMPROVEMENT (RII 4)
PROPOSAL DEVELOPMENT PROCESS

EDUCATION & OUTREACH WHITE PAPER

FOR DISCUSSION
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TITLE: COLLABORATIVE PROPOSALS: SCIENCE INQUIRY WITH VISUALIZATIONS AND INTERACTIVE TECHNOLOGIES

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Collaborative Proposal Part 1: Science Inquiry with Visualizations and Interactive Technologies (SIVIT)

Authors and Affiliations

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Target Audience

The primary audience for the proposed research includes secondary students and teachers in New Mexico with a focus on reaching those who live in rural and typically under-served areas.

Description of Activity

A consistent challenge for learning and teaching science inquiry is providing context that excites learners, extends inquiry, and provides avenues for practical application of concepts. Furthermore, the multidisciplinary nature of EPSCoR research and the complex nature of its content presents compelling challenges for engaging and educating broad audiences. The University of New Mexico's ARTS (Art, Research, Technology and Science) Lab - an interdisciplinary laboratory dedicated to research and development of new media technologies and applications - has a history of achievement in the area of interpreting, visualizing and presenting scientific data for STEM-oriented education within formal and informal learning environments. The Lab has produced interactive software and exhibits, as well as films and other media, relating to a variety of sciences for presentation in museums, science centers, planetariums and other venues. This work is done in a highly interdisciplinary manner, employing artists, scientists, engineers and various technologies in the Lab's robustly outfitted 'Digital Media Garage.'

ARTS Lab proposes bringing its tools, experienced staff, and affiliated faculty expertise to the New Mexico EPSCoR program in order to create a hub for development of data visualizations and software applications to support educational programming and public outreach of EPSCoR-related research. ARTS Lab, as a member of the *Consortium for Fulldome and Immersive Technology Development* (funded by NSF Parnterships for Innovation, 2009-2012), has developed hardware and software that makes it possible to use fulldome and other multi-projector installations as interactive, multi-surface environments that help people visualize, simulate, or experientially comprehend a wide range of information, including scientific data and complex systems. These tool sets enable scientists and educators to create original content for immersive systems and to port existing material into an immersive display with minimal effort.

The DomeGL software developed in the Lab as a result of this research is one of the assets we wish to employ in support of EPSCoR's educational programming. This unique software allows for the utilization of data (informing environment and interaction) and physics (informing simulations) to create accurate, high-resolution, interactive science visualizations for traditional, novel and immersive media. To get a better understanding of what this looks like, please see: http://artslab.unm.edu/research/pfi/activities

Another asset we offer is the design expertise of ARTS Lab Director Tim Castillo (Associate Professor, School of Architecture and Planning) to support creation of interactive applications for mobile devices, personal computers, and novel portable displays. A recent example of Castillo's work is the Virtual Embudo Project, an open-source, GIS-based, multimedia community-oriented website that serves as an interactive tool for accessing historical, infrastructural, geographic, cultural and economic information for a rural village in northern New Mexico. This model empowers communities to visualize and plan for their

future by engaging in conversations with both the local and global public. To learn more about this project, please see: http://timcastillo.wordpress.com/virtual-embudo-project/

Additionally, ARTS Lab recently started work in partnership with Dr. Vanessa Svihla, assistant professor of Teacher Education at the University of New Mexico, to support the assessment of technologically innovative educational products and practices. A recently submitted proposal to NSF's Cyberlearning program, if funded, will take the "DomeGL' software and explore its applications to support interactive, inquiry-lead educational programs that will be designed, implemented, and assessed by Dr. Svihla and her colleagues. Dr. Svihla will leverage her experience designing and researching technology enhanced curricula involving the use of *Interactive Learning Assessment* (ILA) which places students in expert roles, as a model for authentic assessment [Please see SIVIT, Part 2.], as well as her experience developing a triangulation approach to conducting research and studying classroom and design practices. She will also draw upon her disciplinary expertise in geological sciences and climate change to support educators as they design projects.

Deliverables and Relevance to Energy–Water–Environment Nexus

We propose bringing these programs and partnerships together in support of EPSCoR's educational and public outreach programing. As something of a 'nexus within a nexus,' we propose hosting meetings with EPSCoR scientists in order to:

- Discover and articulate learning opportunities afforded by EPSCoR-related research and resulting data
- Explore ways in which immersive visualization and other interactive applications can effectively communicate this research to broader audiences
- Develop plans for implementation based on mutual goals and understanding

Programs may include visualizing data to support education (and, importantly, researchers' discovery processing as well), creating interactive applications for classrooms and the general public, and testing educational experiences for validity and effect. The resulting educational experiences will be disseminated to state schools and other institutions.

Phases and Evaluation

Our capabilities allow us to help scientists visualize their data, and to turn these visualizations into educational materials. We envision the following multi-phase approach in collaboration with Dr. Svihla:

- Phase 1: Develop immersive visualizations in collaboration with EPSCoR scientists.
- Phase 2: Develop educational materials including meta-data and virtual data-collection settings (e.g., virtual stream monitoring equipment overlain on existing data sets) that would allow students to collect the scientific data using immersive and/or interactive technology.
- Phase 3: Embed educational materials in inquiry-based projects that include Interactive Learning Assessments

The effectiveness of these interventions will be evaluated using a design-based research approach, allowing us to refine educational materials to better support learning and to support students in conducting inquiry investigations. The production and assessment efforts will be leveraged in proposals for additional STEM education grants to further augment the EPSCoR program and education within New Mexico and the nation.

Related Funding and Support:

Funded: Google Earth Pro Licenses ($6,000 value), NSF Partnerships for Innovation ($600,000 total)
Submitted: NSF Cyberlearning ($405,000 budgeted)

Possible Leveraged Awards: NSF Informal Science Education (ISE), Innovative Technology Experiences for Students & Teachers (ITEST), NASA Curriculum Improvement Partnership Award for the Integration of Research (CIPAIR), etc.

Collaborative Proposal Part 2: Science Inquiry with Visualizations and Interactive Technologies (SIVIT)

Authors and Affiliations

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Target Audience

The primary audience for the proposed research includes secondary students and teachers in New Mexico with a focus on reaching those who live in rural and typically under-served areas.

Description of Activity

Since the cold war there has been national interest in strengthening pathways to science, technology, engineering, and mathematics (STEM) fields (e.g., Augustine & Committee on Prospering in the Global Economy of the 21st Century, 2005; Rudolph, 2002; United States National Commission on Excellence in Education, 1983), and increasing foci on accountability and testing. This pairing—and systemic moves towards teaching to tests and measuring what is easy to measure—has yielded STEM approaches in school that share little with professional STEM practices.

Professional scientists engage in *designerly* activity as they find problems, pose questions, and plan investigations (Cross, 2001). Current science research often involves large data sets shared by individuals with different expertise and skills, especially when tackling grand, global challenges. STEM professionals collaborate, leveraging distributed expertise and skills to make progress on global issues such as climate change. Students rarely have opportunities to participate in these activities. We propose to help students and teachers participate in *designerly activity* (e.g., posing questions, planning data collection, working with data). Our vision for addressing this need is to provide context and provoke scientific activity using technology, scientific data sets, and authentic assessments embedded in learning. The proposed study will leverage a recent partnership between the ARTS Lab and faculty from UNM College of Education.

We propose the use of *Interactive Learning Assessment* (ILA), which places students in expert roles, as a model for authentic assessment (Svihla et al., 2009). ILA allows students to try on professional roles (e.g., hydrologist, environmental consultant). They use resources (e.g. journal articles, web sites) and apply their conceptual understanding by giving counsel to virtual clients, (e.g., a community concerned about water quality; a company interested in conservation projects). Research has shown that providing authentic, real world context supports learning (Barron et al., 1998; Rivet & Krajcik, 2004), and understanding professional practice helps students persevere through difficult programs of study (e.g., Stevens, O'Connor, Garrison, Jocuns, & Amos, 2008). This design allows assessment of metacognition and ability to use resources to solve problems to which they do not already know answers; in other words, ILA allows us to assess how students *learn to learn*. ILA allows teachers to integrate teaching, learning, and assessment practices in a seamless manner that provides multiple learning opportunities even when testing is taking place.

This is a compelling alternative to traditional assessments that shut down learning time so that students can be tested, with a loss of valuable instructional time.

Deliverables and Relevance to Energy–Water–Environment Nexus

We propose to extend the design of a functional prototype ILA. ILA will allow students to try on expert roles related to energy, water, and the environment. In collaboration with scientists, we would be able to embed real data sets in the ILA for students to work with. The partnership with ARTS Lab will further support innovative uses of immersive and interactive technologies; specifically, these technologies will be used to provide more authentic science context for students working with real data. For instance, immersive technology could provide context for students to virtually participate in data collection; the classroom might be transformed into a spaceship allowing students to search for habitable exoplanets, or a field vehicle capable of reaching extreme environments, allowing students to virtually collect real data for further classroom inquiry (Please see SIVIT Part 1 for more detail).

Phases and Evaluation

We will evaluate the proposed work via mixed methods, using a design-based research approach. This allows us to make evidence-based decisions iterative refinement. Data from ILA will track student progress.

- Phase 1: Design of instructional, inquiry units incorporating existing scientific data sets into Interactive Learning Assessments
- Phase 2: Pilot of units in classrooms
- Phase 3: Integration of immersive and/or interactive technologies to support student data collection, in collaboration with ARTS Lab
- Phase 4: Pilot revised units in classrooms
- Phase 5: Dissemination of findings and of curricular materials

Related funding and Support

Funded: UNM Teaching Allocation Grant for 2012 for the development of Interactive Learning Assessment, $4980

Submitted: NSF Cyberlearning ($405,000 budgeted)